

Non-native Plants of the Plešivica Mountains (Northwestern Croatia)

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Summary

During the floristic research (2003-2006) of the Plešivica mountains (northwestern Croatia) 14 non-native (alien) plants were registered. An analysis of their habitat, taxonomical position, time of immigration, invasive status in Croatia, origin and life forms is presented in this report. Habitats without any alien species are mainly native beech forests, while those with more non-native species are mostly hedge-rows, forest openings and path rims. Half of the taxa belongs to the Asteraceae family and half are therophytes. Eight species are neophytes, all of them invasive alien species (IAS), while the others are archaeophytes. Most of the neophytes originated from North America. The Plešivica mountains is still a very stable forest system, but the most dangerous IAS plants, numerous within human-influenced habitats, representing a potential threat for natural forests.

Key words

Plešivica mountains, Croatia, flora, non-native (alien) plants, invasive alien species (IAS)

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Introduction

Plešivica is situated in the southwestern part of the Zagreb macro-region. It forms part of the mountainous region of the western part of central Croatia (Fig. 1). As part of the Samoborsko gorje massif, its northern area falls within the Nature Park "Žumberak - Samoborsko gorje". Plešivica is about 5 km long arduous ridge, and the highest brow is 777 m (Forenbacher, 1995). The total surface of the researched area amounts to approximately 8 km².

The foothill region of Plešivica, as well as the adjoining mountain chain of Žumberak and Samobor, are made of dolomite and limestone - the same stones that construct the Dinara mountain. Dolomite dates back to the Triassic period, while limestone dates back to the Jurassic period. These massifs are also connected with karst forms in the same mountain system. To some degree, they differ from typical forms of Dinara, because they are overgrown with woodland and their grassy vegetation has been turned into arable land or vineyards (Dujmović-Purgar, 2006). According to the Köppen classification, this area belongs to Cfbwx type C - warm - moderate rainy climate (Crkvenčić *et al.*, 1974). As the Plešivica mountains with the adjoining Samobor and Žumberak mountains is situated on the transition between the south-eastern Alps and the north-western part of the Dinarides, fitogeographically it represents the bridge between the Alps and the Dinarides (Trinajstić, 1995). On highest locations mainly vegetation are forests with *Fagus sylvatica* L. The foothill region of Plešivica belongs to the North American region. In other words her Illyrian province, lower woodland zone links with *Carpinion betuli illyrico-podolicum* (Horvatić, 1967), and these are mainly the woods of *Quercus petraea* L. and *Carpinus betulus* L. Below the zone of the woods on the southern slopes of the Plešivica there are more places with vineyards and cultivated areas and numerous meadows.

The Plešivica mountains flora has not been systematically researched to date. Therefore, the data used for this area have been incidental and sparing, and mainly connected with the research of Samobor and Žumberak mountains (e.g. Schlosser and Vukotinović, 1857; Hirc, 1903-1912; Rossi, 1924; Horvat, 1929). As opposed, the flora of Samobor mountains has been examined well (Šugar, 1972), as well as the one of Žumberak mountains (Vrbek, 2005). The partial research of Plešivica mountains has been done on its southern hillsides from the side of Jaska (Bevilacqua, 1959), and on the weedy flora encircling the settled parts of its southern slopes and the associated plain (Dujmović-Purgar and Hulina, 2004; Dujmović-Purgar, 2006). During the most recent floristic researches (2003-2006) of the whole Plešivica mountains (Vlahović, 2007) 404 taxa of vascular flora has been found. Among them 390 taxa (96%) are native (autochthonous) and 14 (4%) non-native (allochthonous).

Non-native (alien) plants, especially invasive alien species (IAS), are considered the greatest threat to the biodiversity of the flora and its conservation everywhere (e.g. Pyšek, 1993; Pyšek *et al.* 2002, Mitić *et al.* 2006). As the part (continuation) of the first national project about invasive Croatian flora (Nikolić, 2007), here we represent some of those non-native species and discuss their features as well as distribution on the Plešivica mountains, with a focus on invasive alien species. The presence of such species

on particular habitat often is a result of either indirect or direct antropogenic influence. Thus the purpose of this work was to establish if such influence could be identified through the presence of IAS and whether IAS threatens the relatively preserved and stable native flora of the Plešivica mountains.

Material and methods

During the vegetation seasons 2003-2006 floristic researches were done on 20 localities on the Plešivica mountains (Table 1, Fig. 1). Localities were geocoded, their habitats were classified according to Antonić *et al.* (2005) (Tables 1, 2) using standard methods of floristic research (Nikolić *et al.*, 1998; Nikolić and Dobrović, 2002). Plant identification was carried out using the following keys: Hegi (1954), Tutin *et al.* (1964-1980; 1993), Javorka and Csapody (1979), Pignatti (1982), Domac (1994), Rothmaler (1995). Here we present the findings of the research carried out on non-native plants, selected from the whole material and treated according to Dobrović *et al.* (2005; 2006), Mitić *et al.* (2006) and Nikolić (2007). Their nomenclature is according to Nikolić (1994; 1997; 2000; 2007). The list of non-native species (Table 3) includes next data for each taxa: name of the species and the family, the data about origin, the time of immigration (archaeophyte, neophyte), invasive status in Croatia and life form. Data about time of immigration and invasive status of non-native species to Croatia as well as their origin were interpreted according to Pyšek (1995), Dobrović *et al.* (2005; 2006), Mitić *et al.* (2006) and Nikolić (2007). Life forms were interpreted according to Nikolić (2007). Particular data were denoted with abbreviations explained in table (Table 3).

Results and discussion

Fourteen non-native (alien) plants were found in the area of the Plešivica mountains. The presence of these particular species, was documented on 20 localities (Tables 1, 2; Fig. 1), all of them new for the flora of Croatia (cf. Nikolić, 2007).

Habitat analysis (according to Antonić *et al.*, 2005; Tables 1, 2) showed that only five habitats were without any allochthonous species. Those habitats are mainly beech forests (Tables 1, 2; localities no. 5, 7, 9 and 14) while one among them is subatlantic mesophyllous grassland (Table 1, 2; locality no. 3), which implies that those habitats are mainly natural and not invaded with invasive alien plant species (IAS). However, on the locality no. 6 (Tables 1, 2; also forest with *Fagus sylvatica*) three IAS were recorded. This indicates a potential threat on these natural habitat(s) with old beech forests. Habitats with more non-native species in our research (five or six per habitat) are mostly hedgerows, forest openings and path rims (loc. No. 2, 10, 11, 12). Those habitats are known as good places for IAS spread-out (Šoštarić, 1994; Pyšek, 1995) and represent a potential threat for natural forests on Plešivica mountains.

All of the non-native plants from our research are angiosperms as well as dicots, placed within 13 genera and eight families (Table 3). Half of the taxa belongs to the Asteraceae family (6 species, 42,86%), two species belong to the Brassicaceae (14,29%) and several families are represented with one species (Scrophulariaceae, Cichoriaceae, Papaveraceae, Fabaceae, Balsaminaceae, Polygonaceae). This result is in accordance with

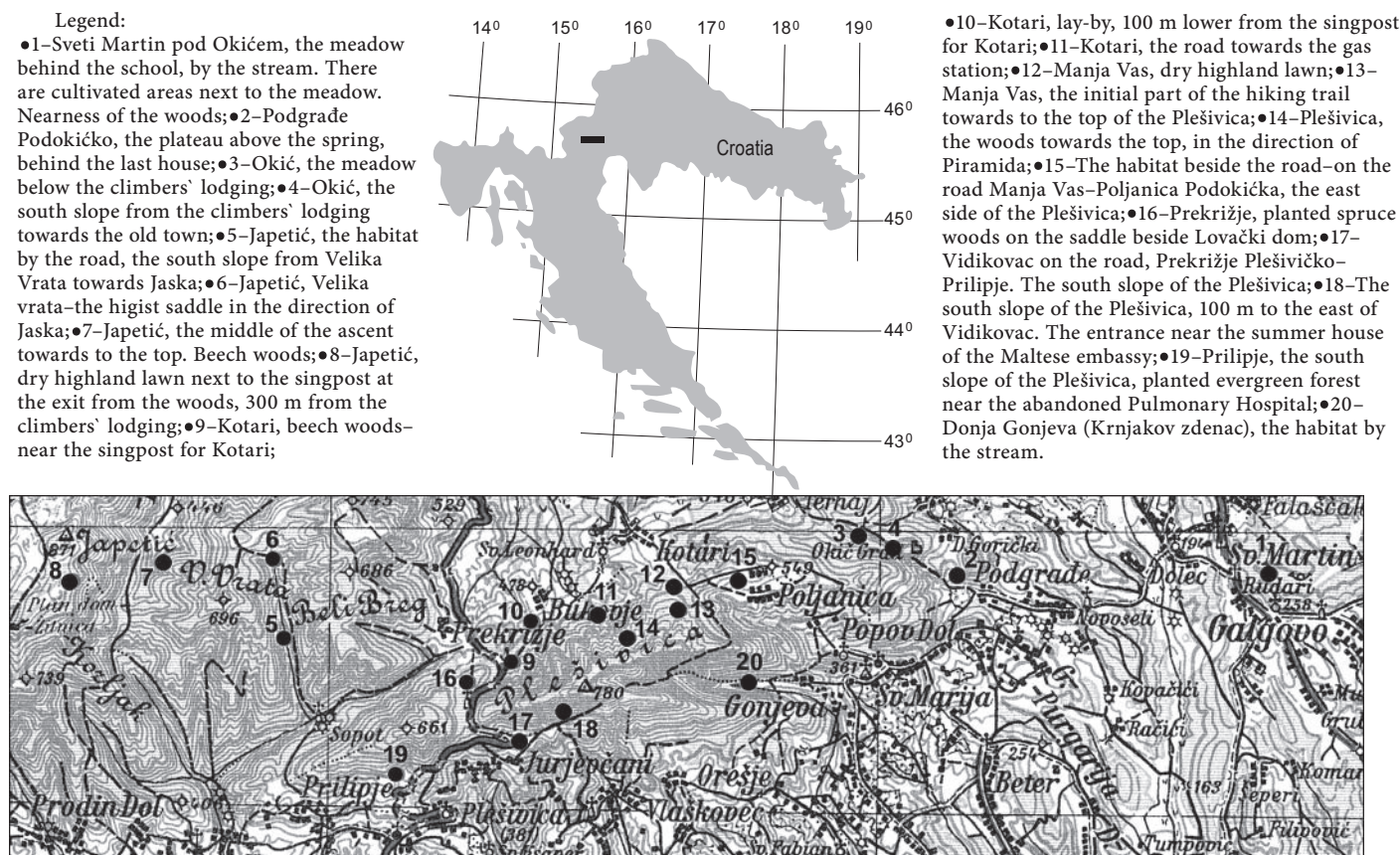


Figure 1. Position of the Plešivica mountains and researched localities (modified according to Anonymus, 1957 and Nikolić, 2007)

Dobrović *et al.* (2005) who suggest that Asteraceae are the most predominant family regarding non-native flora in Croatia.

According to the time of immigration (archeophytes and neophytes) and the invasive status in Croatia, our results (Table 3) showed that a slightly smaller number of allochthonous plants from our research are archeophytes (five species). One species (*Armoratia rusticana* P. Gaertn., B. Mey et Scherb. is cultivated according to Flora Croatica Database (Nikolić, 2007), but also an archeophyte, what could be seen from its historical data (cf. Küster, 1997). Neophytes, arrived after the discovery of America (cf. Pyšek, 1995), are numerous (eight species) and all of them are invasive alien species. Analysis of their origin (Table 3) showed that most of the neophytes originated from North America (five species) while a smaller number originated from Asia (three species). As this still represents only a small number of neophytes on the Plešivica mountains, this result could be accepted with some doubts. However, it is still in accordance with the results about neophytes origin for the whole Croatia (Dobrović *et al.*, 2005).

Life form analysis of allochthonous plants from the Plešivica mountains (Table 3) showed that therophytes were dominant (seven species, 50%, three of them are neophytes), five species (35,7%) were hemicriptophytes, while phanerophytes and geophytes were represented with one species each. Domination of therophytes in our research area is also in accordance with data for the whole non-native flora in Croatia (Dobrović *et al.* (2005).

Regarding the whole flora of the Plešivica mountains, the number of neophytes is low, only 2,1% (Vlahović, 2007), and indicates that Plešivica is still a very stable forest system, in which non-native plants could not easily penetrate. However, we confirmed presence of some, earlier noticed (cf. Dujmović-Purgar, 2006), very aggressive invasive alien plants (neophytes) on the wide area of Plešivica: *Ambrosia artemisiifolia* L. (Tables 1,2; Fig. 1; localities no. 2, 10, 12, 15, 19), *Artemisia verlotiorum* Lamotte (Tables 1, 2; Fig. 1; localities no. 10, 11, 13, 16, 17) and *Veronica persica* Poir (Table 1, 2; Fig. 1; localities no. 6, 8, 11, 20). Those species are mostly therophytes that need light and warmth and prefer to colonize wide areas (e.g. cultivated land, plough-fields, trail and wood margins etc.). Their penetration within stable forest areas is rather difficult (Hulina, 1991), but we found them placed at the edges of plough-fields and vineyards and from there, they could become the biggest threat for an old and/or damaged forest vegetation. Another problem is that *Ambrosia artemisiifolia* and *Artemisia verlotiorum* are aero-allergenic species and should be treated according to propositions for such allergenic species (cf. Peternel *et al.*, 2005). These aero-allergenic species showed a wide spread-out throughout the antropogenic habitats of the Plešivica mountains as well as its foot. They also expanded on the whole area outside the forests (cf. Vlahović 2007). In the present situation, their growth in this area is very aggressive and most likely difficult to stop without radical measures.

Table 1. Non-native species of the Plešivica mountains (explanations: numbers of localities in Legend; code of habitats in Table 2)

Name of species	Locality																			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
<i>Ambrosia artemisiifolia</i> L.		+								+		+			+				+	
<i>Artemisia verlotiorum</i> Lamotte										+	+		+			+	+			
<i>Centaurea jacea</i> L.												+			+		+			
<i>Erigeron annuus</i> (L.) Pers.	+	+				+						+							+	+
<i>Solidago canadensis</i> L.											+									
<i>Solidago gigantea</i> Aiton						+														
<i>Impatiens balfourii</i> Hooker f.		+									+									
<i>Armoracia rusticana</i>								+		+		+				+	+	+	+	
<i>Capsella bursa-pastoris</i> (L.) Medik.	+	+								+									+	
<i>Lapsana communis</i> L.										+		+	+							+
<i>Robinia pseudoacacia</i> L.	+	+		+						+					+	+		+		
<i>Papaver rhoeas</i> L.	+										+									
<i>Polygonum persicaria</i> L.		+											+		+			+		
<i>Veronica persica</i> Poir.						+		+			+									+
Code of habitat	C.2.3.1.	D.1.2.	C.3.3.	E.3.4.	E.4.	E.4.	E.4.5.	C.3.3.	E.4.3.	D.1.2.	C.5.2.1.3.	C.3.3.	E.3.2.1.	E.4.	C.5.2.1.3.	E.9.2.1.	D.1.2.	D.1.2.	E.9.2.3.	C.5.2.1.3.
Co-ordinate x	5555932.65	5555950.60	5555082.96	5555125.32	5548285.72	5548285.72	5548095.60	5547214.74	5551861.52	5551417.75	5555082.96	5553141.61	5553141.80	5553198.68	5552823.32	5551385.42	5551994.76	5551994.76	5551806.17	5554391.99
Co-ordinate y	5067023.13	5067026.53	5067418.93	5067401.20	5066712.56	5066712.56	5066698.75	5066500.63	5065625.46	5065649.58	5067418.93	5067213.80	5067192.19	5067222.34	5067535.27	5066032.13	5065679.05	5065679.05	5066390.64	5065850.71

Legend: 1–Sveti Martin pod Okićem, the meadow behind the school, by the stream. There are cultivated areas next to the meadow. Nearness of the woods; 2–Podgrađe Podokičko, the plateau above the spring, behind the last house; 3–Okić, the meadow below the climbers' lodging; 4–Okić, the south slope from the climbers' lodging towards the old town; 5–Japetić, the habitat by the road, the south slope from Velika Vrata towards Jaska; 6–Japetić, Velika vrata–the highest saddle in the direction of Jaska; 7–Japetić, the middle of the ascent towards to the top. Beech woods; 8–Japetić, dry highland lawn next to the singpost at the exit from the woods, 300 m from the climbers' lodging; 9–Kotari, beech woods–near the singpost for Kotari; 10–Kotari, lay-by, 100 m lower from the singpost for Kotari; 11–Kotari, the road towards the gas station; 12–Manja Vas, dry highland lawn; 13–Manja Vas, the initial part of the hiking trail towards to the top of the Plešivica; 14–Plešivica, the woods towards the top, in the direction of Piramida; 15–The habitat beside the road–on the road Manja Vas–Poljanica Podokička, the east side of the Plešivica; 16–Prekrižje, planted spruce woods on the saddle beside Lovčki dom; 17–Vidikovac on the road, Prekrižje Plešivsko–Prilipje. The south slope of the Plešivica; 18–The south slope of the Plešivica, 100 m to the east of Vidikovac. The entrance near the summer house of the Maltese embassy; 19–Prilipje, the south slope of the Plešivica, planted evergreen forest near the abandoned Pulmonary Hospital; 20–Donja Gonjeva (Krnjakov zdenac), the habitat by the stream.

Table 2. Habitats of researched localities on the Plešivica mountains (according to Antonić et al., 2005)

Habitat code	Explanation
C.2.3.1.	Central European mesophyllous meadows of moderate humidity
D.1.2.	Mesophyllous hedge-rows and scrubs of continental, exceptionally littoral areas
C.3.3.	Subatlantic mesophyllous grasslands, hill's meadows on carbonate soils
E.3.4.	Central European thermophyllous oak -woods
E.4.	Mountain beech woods
E.4.5.	Mesophyllous and neutrophyllous pure beech woods
E.4.3.	Pre-Alpine mesophyllous beech woods
C.5.2.1.3.	Forest clearance, forest path rims
E.9.2.1.	Antropogenic forest associations, plantations of conifers, plantations of common spruce
E.9.2.3.	Antropogenic forest associations, plantations of conifers, plantations of common pine

Another IAS therophyte is species *Impatiens balfourii* Hooker f., relatively new in Croatia, first noticed in Istria in 1992 (Pericin, 1992) and after that in several other areas (Ilijanić et al., 1994;

Nikolić, 2007). In the wider area of the Plešivica *Impatiens balfourii* was first noticed in locality Bukovac in 2002, from where it disappeared in 2006 (cf. Dujmović-Purgar, 2006). We found this species on two localities: Podgrađe Podokičko and Kotari (Tables 1, 2; Fig. 1; localities no. 2, 11). Furthermore, big areas along the roads and paths, as well as lower - altitude meadows were invaded by the IAS species *Erigeron annuus* (L.) Poir. (Tables 1, 2; Fig. 1; localities no. 1, 2, 6, 12, 19, 20). We also registered attractive IAS species *Solidago canadensis* L. (Tables 1, 2; Fig. 1; locality no. 11) and *Solidago gigantea* Aiton. (Tables 1, 2; Fig. 1; locality no. 6) with a slightly lower frequency, which probably escaped from surrounding tilled land. All previously mentioned IAS should be treated as undesirable on the researched territory of the Plešivica mountains as well as in the whole of Croatia (cf. Dobrović et al., 2006; Mitić et al. 2006) and should be included in future measures of their monitoring and treatment (e.g. eradication).

However, in case of management with *Robinia pseudoacacia* L. species (in our researches found in (Tables 1, 2; Fig. 1, localities no. 1, 2, 4, 10, 15, 16, 18), pretty patience should be applied, because of its double «role». Namely, on one hand, it is little known that this wide-spread species is IAS for native forests

Table 3. Non-native species from the Plešivica mountains (neo–neophyte; arh–archaeophyte; cult–cultivar; IAS–invasive alien species; N. Am.–North America; T–terophyte; H–hemicryptophyte, P–phanerophyte, G–geophyte)

Name of the species	Family	Time of immigration	IAS	Origin	Life form
<i>Ambrosia artemisiifolia</i> L.	Asteraceae	neo	+	N. Am.	T
<i>Artemisia verlotiorum</i> Lamotte	Asteraceae	neo	+	Asia	H
<i>Centaurea cyanus</i> L.	Asteraceae	arh			T
<i>Erigeron annuus</i> (L.) Pers.	Asteraceae	neo	+	N. Am.	H
<i>Solidago canadensis</i> L.	Asteraceae	neo	+	N. Am.	H
<i>Solidago gigantea</i> Aiton	Asteraceae	neo	+	N. Am.	H
<i>Impatiens balfourii</i> Hooker f.	Balsaminaceae	neo	+	Asia	T
<i>Armoracia rusticana</i> P. Gaertn., B. Mey. et Scherb.	Brassicaceae	cult			G
<i>Capsella bursa-pastoris</i> (L.) Medik.	Brassicaceae	arh			H
<i>Lapsana communis</i> L.	Cichoriaceae	arh			T
<i>Robinia pseudoacacia</i> L.	Fabaceae	neo	+	N. Am.	P
<i>Papaver rhoeas</i> L.	Papaveraceae	arh			T
<i>Polygonum persicaria</i> L.	Polygonaceae	arh			T
<i>Veronica persica</i> Poir.	Scrophulariaceae	neo	+	Asia	T

(Dobrović *et al.*, 2006; Nikolić, 2007). But, on the other hand, it has been planted and used for firewood, vineyards props (Lang, 1911), to secure dry and waisted soils (Šoštarić, 1994), and today is one of the most important honey plants in Croatia (Bačić and Sabo, 2007).

We can conclude that the area of the Plešivica mountains is mostly a very stable forest system, which cannot be easily penetrated by non-native, especially invasive alien plants. However, the most dangerous IAS plants are present within human-influenced habitats on the Plešivica mountains. Without any management measures, they could become the biggest threat for all habitats and can easily invade and threaten natural forests and their biodiversity. After such a probable “scenario”, any further measures against IAS on the Plešivica mountains may be a “lost game”.

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